MODELLING OF IONOSPHERIC ERROR CORRECTION FOR RELATIVE GNSS MEASUREMENTS

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ABSTRACT

A new approach to the precise determination of the differential ionospheric error (between spaced receivers) to sub-centimeter accuracy is described in this paper utilizing a developed model based on the ray tracing method. For the standard single frequency Differential GPS method, where dual frequency receivers are not available, perhaps for reasons of cost, GPS measurements are made at two spaced receiving stations, one of which (the reference station) is at a surveyed location. Then the delay introduced by the ionosphere at the reference receiver can be used to correct the range measurement at the second (mobile) station. This assumes that the effect of the ionosphere is the same for these two closely spaced paths from the GPS satellite, so that this method is accurate only for short baselines where the ionospheric error is well correlated. For longer baselines, it is important to consider also the effect of horizontal electron density gradients. For the most accurate positioning using GPS phase measurements, it is important to correct more accurately for the ionosphere error source taking into account the two different paths through the ionosphere to the reference and mobile receivers. An ionospheric correction model has been developed to accurately determine the difference in ionospheric delay expected over a short baseline so that a more accurate differential GPS correction can be made. Very precise ray paths for both group and phase have been determined utilizing a modified Jones 3-D ray-tracing program, which includes the effect of the geomagnetic field together with a Nelder-Mead algorithm to home in precisely on the satellite to Earth station path in each case. The ionospheric model used in the ray tracing is determined by fitting realistic ionosphere profiles with a number of exponential functions. The use of base exponential functions considerably improves the ray-tracing accuracy, which is essential. Horizontal gradients have been investigated by introducing linear gradients in the ionospheric electron density. These results have been used to provide a method of modelling and correction of the ionospheric error. The developed algorithm is a function of elevation angle and TEC and is therefore applicable to any location. The efficacy of this model has been evaluated using real GPS measurements recorded by the European GPS network. The application of this model to real GPS data recorded at spaced stations in Glasgow (UK) and Stirling (UK) has been investigated in detail. Results show that the implementation of this model improved the ambiguity resolution rate and also improved the quality of the differential positioning solution in terms of variance ratio and reference variance. Significant improvements by more than 50% have been achieved by correcting the differential ionospheric delay in the measurements for the estimated position using this new method compared to single frequency measurements which are uncorrected for the difference in ionospheric delay between the paths to the mobile and reference receiver locations.